Preparation and In-Class Intervention Programs for Barrier Courses for Two-year College Engineering Students

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Abstract

Students enrolled in community college engineering programs in California typically have a long path of prerequisites to overcome before they are able to enroll in transfer-level engineering courses due to under preparation when entering college. The courses required for the engineering path involve many courses with high drop, withdraw, and fail rates, which can lengthen the time needed to complete transfer coursework. At Cañada College we found that even students that ultimately persisted were attempting courses such as trigonometry and physics multiple times before they were able to successfully pass the courses. These challenges inhibit the students' ability to complete the necessary requirements for transfer in a timely manner, if they are able to complete them at all. We have chosen to address these issues by developing two methods of academic support. The first is to prepare students prior to the start of the semester, and the second is to offer continued support for the duration of the semester.

Pre-semester preparation is offered through one of the free Jam programs available to all campus students. A specific example is Physics Jam, which is a pre-semester self-paced boot-camp program to introduce and review the necessary math requirements for the physics class in which they are enrolled. This math review is also coupled with intense study-skills workshops to teach students how to approach their upcoming course. This program allows students some extra time with the introductory material for their upcoming courses as well as the necessary reading and problem-solving skills that they will need to be successful in their course. In addition to the Jams, continued academic support is offered once students are enrolled in the course.

In-class academic support is offered in the form of a novel, modified Supplemental Instruction program that is called Embedded Peer Instruction Cohort, or EPIC for short. It has been shown that for STEM fields student success is higher when they work together as groups outside of class as opposed to studying alone. The EPIC program focuses on having student leaders go over examples in pre-scheduled weekly study groups and encourage students to work on these problems together. The aim is to encourage students to develop the confidence to tackle difficult problems and the skills and the knowledge to work together to obtain a solution. This program is separate from tutoring and focuses on how to approach and work through problems as opposed to one-on-one topic remediation. Students that participate regularly in EPIC program perform better than their colleagues who do not participate in the program.

This paper will discuss the successes, obstacles, and best practices in developing and implementing academic support programs for two-year college engineering students.

1. Introduction

There is a large push from multiple directions to increase the number of students in the United States graduating with STEM degrees. Recent projections show that there must be a 34% increase of students graduating in STEM fields within the next decade to allow the US to remain competitive on the world stage. [(1)] There are numerous academic routes for students to enter a STEM field and due to the rising cost of traditional 4-year degrees, a 40% increase in tuition, room, and board between 2002 and 2012, [(2)] and low income and first generation students seeking out local educational opportunities, many of these students are starting their path at two-year institutions. Unfortunately, many students starting on the STEM path are underprepared to take the challenging STEM courses after they complete high school. [(3)] When looking at the performance of specific demographic groups independently in the Silicon Valley region of California, only 24% of Latino and 27% of African American students reached the academic requirements set by The University of California (UC) and California State University (CSU) systems. This is in stark contrast to the 70% of Asian and 57% of Caucasian students that meet the requirements. [(4)] These trends can be extrapolated to STEM courses specifically as well. Cañada College is a federally designated Hispanic-serving institution (HSI) and serves a diverse population of students that are frequently under-prepared for college-level work, in particular physics and transfer-level STEM courses and their pre-requisites.

As an example, students beginning their preparation for a degree in engineering at Cañada College must complete a series of transfer-level math classes that include Trigonometry, Pre-Calculus, Calculus 1-3, Linear Algebra and Differential Equations. In addition to the math requirements students must complete at least one semester of chemistry, and the calculus-based physics series. A student who starts college needing remediation has a long academic journey with additional challenges before completing the courses needed to transfer to a 4-year institution. At Cañada College success rates for these pre-requisite gate keeper courses are low. Before implementing the comprehensive pre-semester preparation and in class support the success rates for select engineering course pre-requisites during the spring semesters averaged over 10 years are listed in *Table 1*.

Table 1: Success Rates of select Engineering Prerequisite Courses

Course	Average Success Rate Springs 2002-2012
Trigonometry	51.39 %
Calculus 1	69.02 %
Physics 1 with Calculus	63.03 %
Physics 2 with Calculus	77.14 %

Cañada College, like many other community colleges, does not offer any course to help students prepare for STEM courses such as Physics. All students must do is successfully complete required pre-requisite courses which does not always indicate future success. It was with this in mind that the Embedded Peer Instruction Cohort (EPIC) program, a new in-class support environment was initiated during the Fall 2013. The following semester Physics Jam and a pre-semester physics preparation program was implemented. The goals of both of these programs are to teach students how to be successful and to improve their persistence and success in the STEM courses they enroll in so they can successfully and efficiently complete the engineering pre-requisite courses and move on to their transfer-level engineering courses with a strong foundation.

2. Physics Jam

The goal of Physics Jam is to improve the success and retention rates of students proceeding though the calculus-based physics course sequence. The initial development involved determining the barriers to physics student success. The main barriers were identified as not previously having seen math concepts that they needed for their physics course, such as vectors, or being presented this material in a new way. To address these issues a free voluntary one-week pre-semester program was developed, and that all calculus-based-physics students were encouraged to participate. Physics Jam employs a multifaceted approach to address math deficiencies, and give students a head start on physics concepts. The skeleton of the program uses adaptive online programming that starts students off on a math review and an introduction to the math concepts they will need to employ in their upcoming course. The math review portion takes most students 2-3 days of the 5 day program. Once they have completed the math portion they proceed to learning some of the beginning concepts that they will be learn in their upcoming course. And finally they work on example problems to get practice and exposure to the types of problems they will be dealing with during the semester. Based on information from entrance and exit student surveys the program helps students build the confidence that they can handle the material and encourages them to think positively about their upcoming course. The program is administered by a Physics instructor, and students that will be serving as physics tutors in the upcoming semester. This not only gives the students an opportunity to meet available tutors but serves to help train and prepare the students tutors in an environment where they have instructor backup whenever needed. The online modules are supplemented by group activities and mini-lectures given by the instructor.

The math portion of Physics Jam is hosted in the MyMathTest environment. Modules are pre-prepared for students to cover the concepts that they will need for their upcoming physics course. For Physics 1 this includes vectors, basic trigonometry, and basic differentiation techniques. The Physics 2 module includes the Physics 1 math and also incorporates integration techniques as well. The review of Physics 1 math is especially useful because many students do not take the second semester physics course immediately after the first. The MyMathTest program allows the instructor to develop a pre-test that covers all of the previously mentioned topics. Once the

student completes the pre-test the MyMathTest program puts together a study plan based on the questions that they missed. This allows the student to efficiently use their time to brush up on the concepts that they have forgotten and not spend as much time on concepts that they are comfortable with. For most students this program is the first time that they are comprehensively introduced to vectors. At Cañada College students would be introduced to vectors at the end of their trigonometry course, but unfortunately it is a topic that instructors do not have enough time to cover well, or at all, so most students see vectors for the first time during the first week of their physics course. It is for this reason that group work and activities at the beginning of the week center on a complete introduction to vectors, their notation, and how to work with them. Feedback from first semester faculty indicates that the students who have participated in Physics Jam are easily identifiable and end up helping their classmates during the vector introduction in the course. Once the students complete their designated study plan on MyMathTest they take a post-test to see their improvement. Students averaged a pre-test score of 62% and a post-test score of 89% for the Winter 2015 Physics Jam, and these are typical results based on previous iterations. The entire program is self-paced and students are allowed to spend as much time as they want on any one portion as long as they are still making progress. Once students complete their math review they can continue on to their physics introduction.

The remaining Physics Jam content is contained within Cañada College's online Moodle environment. Schedules, suggested paths, and links to resources and videos are preloaded in the online Physics Jam course. Students are directed to watch some short video lectures on introductory physics concepts from resources such as Khan Academy, YouTube, and Hippocampus (http://www.hippocampus.org/). It is at this point that students can begin working on some online practice problems through WebAssign which is an online homework system that gives instant feedback to the student and uses books problems that align with content that will be presented in the course. When students are first presented with physics problems they frequently respond with negativity associated with "word problems" and not understanding what is expected. It is at this point in the week that Reading Apprenticeship (RA) workshops are included. RA is a program developed by WestEd and has been shown through research to help students succeed in specific subject area courses by learning from their instructor how to approach the material that they is being presented. [5] In short, by an auditory example the instructor reads aloud a section of a book chapter and example problems verbally annotating what they are thinking while they are reading to demonstrate to the student how to best read for understanding. The point is to show inexperienced students how they should be approaching written material in a course such as physics. The students then pair up and practice reading in this manner to each other. Initially this portion was met with a bit of skepticism from the students, but at the end of the program this RA module is highly rated in the exit survey.

With the iterations of Physics Jam already implemented students who participate in the program are more successful in their upcoming physics course than their classmates that did not participate. For the Spring 2014 semester physics 1 students that participated in Physics Jam

were approximately 44% more successful than their colleagues that did not participate. Students in Physics 2 that participated in Physics Jam were also more successful. Overall students who participate in the Physics Jam program succeed at higher rates than their comparable classmates that do not participates. Success rates for students who've participated in the Physics Jam program can be seen in Table 2.

Table 2: Comparison of Success Rates for Students based on participation in Physics Jam

	Percentage of Students Successful Completion of Course	
Course	**Students that participated in Physics Jam**	**Students that did not participate in Physics Jam**
Physics 1 With Calculus	75%	53%
Physics 2 with Calculus	89%	82%

A longitudinal study that explores students' performance in other STEM courses before and after should also indicate the effectiveness of this program and eliminate any questions about how much of student success could be attributed to the program or to the fact that successful students are more likely to take advantage of available resources. As has been shown here preparing students before the semester is a useful tool to help promote students success. However, not all of our students that need extra help are willing or able to participate in an intensive pre-semester workshop. It is for this reason that in-class support was also incorporated into services offered for the pre-requisite courses for engineering. This in-class support is offered in the form of the Embedded Peer Instruction Cohort Program.

3. Embedded Peer Instruction Cohort

Some studies have shown that the typical two-year university student has less campus involvement, persistence, grit, and success when compared to their four-year university counterparts. [(6)] Creating programs that get students on campus working together helps to promote their success. The Embedded Peer Instruction Cohort (EPIC) Program is based on a modified supplemental instruction curriculum. Supplemental Instruction (SI) has been extensively studied as a successful means of improving drop withdrawal fail (dfw) rates in introductory courses. It is particularly successful for large lecture humanities courses, and other classes such as Biology; however the modifications need to be made to attain success in math and other problem-solving-based courses. [(7)] The EPIC program structurally looks the same as SI in that students who were previously successful in a course are selected to be EPIC leaders. EPIC leaders at Cañada College were faculty-recommended students who received an A in the course, had an overall GPA of 3.5 or better, have outgoing personalities, and have the ability to convince students to attend their sessions. These EPIC leaders attend class with their students and also hold 3 hours of what we call "study sessions" each week. The difference between EPIC and

traditional SI begins with what happens during the EPIC sessions. EPIC leaders are not designated as tutors, but they are allowed to answer student questions during the sessions. Each week the EPIC leaders prepare some example problems to go over with the students so that students get practice on solving problems for their course. The primary role of the EPIC leader is to facilitate the students working together in groups to solve the problems rather than solving the problems for the students. The EPIC leaders are also specifically trained to offer modules on studying for their specific class/instructor, Reading Apprenticeship and encouraging students to work together to solve problems. At Cañada College like many other institutions it can sometimes be difficult to get students to attend voluntary sessions that occur outside of class and we've developed a few different ways to encourage student participation.

Currently our EPIC leaders are paired with all sections of Trigonometry, Pre-Calculus, Calculus 1, Physics 1 and Physics 2. The instructors in these courses have been informed of the program and its potential benefit to their students. These instructors have welcomed the EPIC program into their classrooms and have encouraged their students to participate in the EPIC sessions. Instructor participation is crucial and much easier for a full-time faculty member who spends more time on campus compared to an adjunct faculty member who may be teaching at a number of campuses and do not have the extra time required to get students motivated to attend. Many of the instructors will offer worksheets and other problem resources to their EPIC leaders to cover during the session. This translates to students "getting extra resources" for attending EPIC sessions and getting to work on content specifically selected by the instructor for their course. Classes where instructors are heavily involved in recruiting students to the sessions have high regular turn out rates. Some of the instructors even drop by sessions to work with the students, which is generally seen by the students as an extra advantage to attendance. An overwhelming majority of students that attended an EPIC session for their course attended multiple sessions throughout the semester. To encourage student attendance from the beginning of the semester they will be offered a pizza party for averaging attendance to at least 1.5 sessions per week for the first month of the semester that EPIC is offered. So far this resource has been welcomed by many of the students and offering these group sessions instead of one-on-one assistance has helped us to more economically serve our the students throughout the semester.

We are currently in the process of analyzing the effects of participation in the program and any potential effects on course performance. In some sections students who attend EPIC sessions perform better than their colleagues who do not, but in other sections students that participate have lower average grades than students who do not. The second reason is more compelling because it could indicate that students who are attending are the students that are in need of help and the group that we most want to target. From end-of-semester surveys, reasons that students did not attend were either they had the grade that they wanted and did not feel like they needed to attend, or that the sessions were at a time that they could not come. Every effort is made at the beginning of the semester to schedule sessions around the student and EPIC leaders schedule

through an online availability reporting survey. Success of students who have attended vs those who did not attend can be seen in Table 3.

Table 3: Success of students in course based on EPIC participation

	Participated in EPIC	**Did Not Participate in EPIC**
Trigonometry	58%	33%
Pre-Calculus	100%	60%
Calculus	56%	80%

Ideally having students who are doing well in the course attending EPIC sessions is beneficial to all students. This is because students that are struggling can benefit from extra input of their colleagues that are a bit ahead, and more advanced students benefit from having to really think about their answers to explain it to the other students. Overall one of the main successes of the program so far is getting students who traditionally did not engage in the campus academic resources to come to the STEM Center to work together with their colleagues and instill positive study habits.

4. Conclusions

STEM students attending two-year institutions need extra incentive and encouragement to get involved on campus and promote their academic success. They are frequently under-prepared for the rigor of STEM courses and this consequently leads to lower retention and persistence levels. Both Physics Jam and The EPIC Program have offered Cañada College's students the opportunity to learn how to be a successful student and the importance of working together to promote their success. We have demonstrated that programs such as these can be successfully implemented at a small two-year institution and that students can be encouraged to participate in voluntary academic support programs. Cañada College is a relatively small institution and continued efforts are underway to evaluate the impact of these programs on student success, persistence, and GPA.

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